

GG425 -- ENVIRONMENTAL GEOCHEMISTRY
Spring 2008
 Answers to Homework set #3

1a. What is the instantaneous ("Streeter-Phelps) BOD in mg O₂/L of an anoxic waste stream containing 0.02 gm/L labile dissolved organic carbon and 0.015 gm/L particulate organic carbon of which 30% is readily digestible (rest is refractory) as it dumps into a river. Assume a 10 fold dilution of the waste stream when it interacts with the river.

*Labile organic carbon (OC) = 0.02 g/L + 0.3 * (0.015) g/L = 0.0245 g/L
 10 fold dilution makes this 0.00245 g/l.*

O₂ to Carbon consumption ratio of 140mg/100 mg (or 1.4 to 1) means that 0.00327g/L O₂ would be consumed by this waste stream after mixing with fresh water

1b. If the river water is at 25°C, was saturated with O₂ upstream of the effluent outfall, was moving very slowly and experience no aeration across its upper surface, would this water become eutrophic after interacting with the waste stream?

8.6 mg/L - 3.43 mg/L = 5.17 mg O₂/L, or 60% of saturation - not eutrophic

2. Examine the dissolved O₂ profiles in the Thames estuary in Fig 5.26 on page 13 of the lecture 16 pdf notes. Assume that 100% O₂ saturation is to 2.1 x 10⁻⁴ moles/liter O₂ in the river water.

a. Estimate the % of saturation for O₂ from this plot and then calculate the O₂ concentration in this river water (in moles/liter) in 1893 (the first datum), 1930, 1950 and 1970 for the two locations shown.

(My values are approximate - I accepted anything that was close)

Year	95 km below weir	79 km below weir	95 km	79 km
	approx O2%	approx O2%	O2 conc - M	O2 conc - M
1893	88	59	1.85E-04	1.24E-04
1930	98	38	2.06E-04	7.98E-05
1950	75	7	1.58E-04	1.47E-05
1970	85	44	1.79E-04	9.24E-05

b. assume that the stoichiometry of the Redfield ratio for photosynthesis/respiration controls the concentration of both O₂ and PO₄ in this river. If the concentration of PO₄ at 100% saturation of O₂ was 1.1 x 10⁻⁸ moles/liter in this water, what was PO₄ at each point along the two profiles in this river for the time periods you examined in part "a"?

Redfield gain in PO₄ = loss in O₂/138, So for part B, you use the relationship: (change in O₂)/138 = - (change in P). note: Change in P is that which must be added to the standing crop in the water as O₂ is utilized

O₂ initial = saturation, O₂ final = the observed value

P initial = P left at O₂ saturation (a very low amount)

P final = P initial + P added by respiration -----> 1.1E-08M + (change in O)/138

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Year	95 km	79 km
	Tot PO4	Tot PO4
1893	1.9E-07	6.3E-07
1930	4.1E-08	9.5E-07
1950	3.9E-07	1.4E-06
1970	2.4E-07	8.6E-07

c. calculate the rate of change of O_2 along the two profiles in this river for the 3 time intervals 1893 to 1930, 1930 to 1950, and 1950 to 1970. Rationalize the values and their difference

Year	95 km	79 km
	rate of O_2 change (M/yr)	
1893		
1930	5.7E-07	-1.2E-06
1950	-2.4E-06	-3.3E-06
1970	1.0E-06	3.9E-06

Overall this is a signal of an increasingly overburdened urban sewage treatment system that was subsequently improved enough to keep the Thames from going eutrophic by the latter part of the 20th century. The location further down river experienced lower effective BOD (and thus higher Dox) throughout the entire period because the near-point source OM load from London was at least partially decomposed by the time the river flowed by that location. There is a small rate of change in the first time interval in both areas probably due to similar BOD load, increasing to more oxygen depletion in the second interval from increased BOD load, to improving conditions in the final period as better effluent control measures were put in place. Rates of change are more extreme at 79 km below the weir, as expected by the lower absolute concentration.

3. Chapter 5 problems: (everyone did these well, so there's no point in giving answers here)

4. Explain the possible fates of 3 different metal ions in the sediments of the same estuary:

- a) a metal adsorbed to clays that were flocculated in the estuary
- b) a metal ion bound to amorphous Fe-oxyhydroxide colloids
- c) a metal ion bound to flocculated POC

all 3 materials will flocculate, taking their bound metal with them to the estuarine sediments. In general, POC flocculates first, followed by Fe and then clays, so metals bound to each will be found in (overlapping) bands as one moves down river. Redox changes in the sediments can affect sorption behavior of the metal in all 3 cases if it is a redox sensitive element.

metal adsorbed to clay. This may be come salted off of the clay particle if eroded down stream to higher salinity waters, but otherwise the metal will likely stay adsorbed.

Metal bound to FeOOH colloids. These tend to stay put until the point where redox changes cause Fe+3 to transform to Fe+2, at which point the metal will desorb to sediment pore waters.

Metal bound to DOC. Similar story. The metal stays put until the POC is decomposed by sediment-dwelling organisms, at which point the metal may become incorporated into their bodies or released to the pore waters.